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A COMPLETE SET OF NOTES

ON

BOTANY.

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NOTES ON BOTANY.

Lecture I.—Botany and Zoology are sister sciences and together constitute Biology. They often coincide and agree in many important particulars. The scientific study of plants is of later origin than that of animals, there being nothing done until 1519 (about the time of the Reformation) when accuracy was sought in description. John Ray came next in 1686. He was far ahead of his time, and it was his collection of plants, &c., which was the beginning of the British Museum. He did not have a convenient terminology. In 1737 Linnæus introduced the binomial system of nomenclature, arranging his terms so as to obviate repeating descriptions. He also molded the Latin Language so as to be a convenient vehicle for carrying Science. There were four languages available to Science, Latin, French, German, and English: Linnæus was a Swede, hence used only Latin, but his style was a model, and his language easy to understand, since when he used a phrase for any one thing he did not vary that use. (No verbs are used in Scientific Latin.) His classification of plants is somewhat artificial, but easy to learn, though it is dangerous because it postpones the difficulties, and it has retarded Science. In 1789 Jusseau introduced the correct system. This has been extended by Decandelle and Torrey, and was used by Asa Gray in America. Germany has also done good work in the lower orders. Botany is in some respects a more difficult study than Zoology, but like it, it trains to intellectual accuracy, and is productive of pleasure.

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The question occurs " What is a plant." It may be answered in a certain way by almost anybody, but it is difficult to answer correctly. The lower orders of plants run so closely into the lower orders of animals that it is difficult to tell where animal life ends and the plants begin. Some animals do not move, while, in their early stages, some plants do, so that what would seem the most obvious test here fails.

We have first to state what are the marks which distinguish Organic Nature (including Animals and Plants) from Inorganic Nature, (including Minerals, &c.)

First, Plants, &c., have an organized being, cellular in structure. Plants and animals are alike in this, that they have a cell-structure, and a *protoplasm.* The form of the cell varies. Some cells have no wall, but are a mere mass. Oftener they have a wall and a definite shape. Minerals, on the other hand, are crystalline and have not a cell structure.

Second, the chemical constituents are restricted or definite. We always find three things present, viz.: hydrogen, carbon, and oxygen in all parts, and in the growing or living parts we find nitrogen. We also often find iron and sulphur. In minerals the chemical constituents vary indefinitely.

Third. The former grow, changing internally. If we take a cell, it is believed that the wall consists of Molecules and an atmosphere of water around it, and this enlarging, brings about the growth. Minerals do not grow, but may have superficial additions. The fourth point is that plants and animals live. Minerals do not. The fifth, that plants take food from without themselves. Thus a germ or seed becomes a tree. Minerals can not take food or use it.

Sixth, plants, &c., reproduce their own kind. Minerals do not. Seventh, plants and animals have definite outline, and that is generally curved. The forms of minerals are varied, outlines straight, angular, or irregular.

Now as to the characters which distinguish plants from animals. As stated above, some animals resemble plants so nearly in some stages of their growth that it is very difficult to tell where the animal kingdom ends and the vegetable kingdom begins. No definite and .satisfactory line can be given, as all attempts to establish differences have failed. Still some general points may be given as follows.

First, Food. Both plants and animals feed, and consume the same kind of food. But the plant alone produces food, and this the *animal* can not do. But plants can also live on minerals, and in fact *do* take in food from the ground. Hence arises the theory that the universe is going to ruin, everything tending to be consumed, Plants are engaged in laying up a store of food for future use, manufacturing it as they go. They get force for this from the sun. It has been found that plants thrive under the influence of electricity. As it is true that there are some parasitic plants, what would otherwise be the best general distinction between plants and animals, viz.: that the plants produce food and animals do not, fails.

Second. Their action on the air. It was once supposed that plants consumed carbonic acid and animals oxygen only. This subject has been much misunderstood, just as it was supposed that animals knew antidotes for poisons.

Aquariums have been supplied on this principle. Plants do pollute the air at night, but only a very little, giving out carbonic acid. They consume oxygen day and night, but unlike animals, which consume but do not furnish food, they give out more oxygen than they consume. It is only while green that they can do this. The green color is given by a large number of minute green particles.

Third. Food, Motion and Sensation. Here again distinction fails. Some of the lower animals do not manifest sensation, while it seems to have been proved that the root of a plant is sensitive as it moves aside to get rid of an obstacle. Darwin says that he tried an experiment with a rootlet and a piece of paper and always found the rootlet move aside to avoid the paper. Sensitive plants seem to have sensation, and so most plants fold their leaves at night and so retain heat. Then, as mentioned before, some plants are fixed, while other plants seem to have at some periods of their existence, the power of motion.

Fourth. In plants there is starch in abundance throughout the cell. This distinction does not hold throughout, as some plants are found without starch while it is found in animals, as, for example, in the human brain.

A fifth point is that in animals there is more nitrogen than is found in plants. Hence, as we see, there are no definite marks of distinction between animals and plants. Plants are midway between Minerals and Animals. They, as already intimated, are ahead in that they manufacture food, and are an absolute necessity as without plants there could be no animals. The secret of plant-life is not discovered, and its operations are to a great extent a secret, and afford scope for much original research. Old theories are being disproved ; as for example it used to be thought that every plant was a medicine and that every poison had an antidote. Botany, or the Science of Plants, deals with their structure, classification, physiology, distribution, and uses. We follow lines of affinity in assigning organisms to animal or vegetable kingdoms.

Lecture II.—The structure of plants is much simpler than that of animals and hence the science is easier to master. If we have a good knowledge of the parts of one plant, we have a good knowledge of Botany. Hence to watch carefully and note the changes in a single specimen will make us better acquainted with the real science than the reading of many books. In this science we must have precise termi-

nology, and must make use of it, hence it is that the terms in Botany give more trouble than in Zoology, there being more scientific terms new to the student.

We consider plants under two aspects. (1.) The form of structure. (2.) The function or work of those parts. When parts are of same nature, we say they are homologous, and that without regard to their functions. Thus floral and foliage leaves are homologous. When parts have the same work, we say they are analogous. The distinction between homology and analogy must be carefully noted. The most important department of Botany in study is in regard to the structure, the homology of plants. We have four classes of structure, viz: (1.) The roots or descending axis and its branches. (2.) The stem or ascending axis and its branches. (3.) The leaves and their branches borne by the stem; and (4.) the hairs and their branches. Sometimes these hairs are very beautiful, as may be seen on the leaf of the ivy in great abundance, where it is star shaped. As regards function we may divide all parts of a plant into two classes, viz: (1.) Organs of nutrition, such as the stem, root and green leaves; (2.) Organs of reproduction, as the flower, producing fruit. The flower includes axis, leaves and hairs. The important point to notice in regard to hairs is that they are outgrowths of the surface, not penetrating the inner parts. Thus the thorns of roses are really hairs. So the cotton of the cotton plant is really a growth of hair on the seeds. The spines of many trees are not hairs, as for example, the locust. These bear leaves, hence are not hairs, as they do not grow from the surface. Hair in plants and animals is not at all homologous, but the name given to this growth in plants is simply conventional. They vary much in different plants, some have spiral hairs, some star-shaped, and some have a little cell at their base containing liquid, as in the nettle. Having now considered *hairs*, three parts remain to be studied. In the lower classes of plants there appears no distinction between root, stem and leaves. Those having no distinction between stem and leaves have an expansion, as the top of the mushroom, called a thallus, meaning an expansion, and are called Thalloges. This is the first class, the second class comprises the leaf-bearing plants, which will for the present occupy our attention. The histology of a plant is the microscopic structure of that plant, of its stem and leaves. The simple vegetable cell with cell-wall and protoplasm is the structure from which all plant life comes. These cells assume different forms. (1.) Short cells, found in the leaf and pith of plants. The parts where growth takes place is mostly of short cells. The edible parts of plants are mainly of short cells. (2.) Long cells or fibres, in shape are larger in middle and pointed at each end. They are hardened and make wood, and are also found in the inner bark, but there are tough and called *liber* cells. Linen, hemp, flax, jute, &c., are of this kind of cell, and it is very abundant and most useful to man. Their strength is immense, and new varieties are being constantly found. It is these fibres that make veins in leaves. (3.) Ducts—tubes open at both ends, having a thin wall variously marked. They carry fluid (the sap) in Spring, and in Summer carry air. Some ducts are found containing a spiral fibre, and are called tracheae. They are found next the pith and often in leaves. (4.) Flat cells which make the skin, have mouths for breathing, called stomats. The fibre-vascular bundles found on the skin of the palm are of this character. Between the cells are spaces filled with air and crystals of lime.

The Axis and Leaves.—The axis is made up of pieces of stem-bearing leaves, and the places where these join are called nodes or knots, and the pieces of stem are internodes. Each plant is made up of a series of these, the leaves coming out at the nodes. A bud is a stem bearing leaves; the

stem elongates, puts forth its leaves and becomes an axis. All variations of the parts come from these. Variations in color plays an important part in the life of the plant.

Root.—This is sometimes very long. The white clover sometimes has a root 20 feet long. The root is the part which first appears from the seed. Its uses are (1.) to fix the plant in the soil; (2.) to get moisture; (3.) to get food. As soon as seed germinates it sends down a root to fix itself and store moisture, but lives for some time on the food stored up in the seed, hence it is that plants spring up along the wayside and thrive for a time, and then die. The food in the seed is exhausted and the soil is too hard to afford sustenance. The place where roots grow is not at the top of the root, but just behind the tip, which acts as a cap for the protection of the growing rootlet. The rootlet pushes the cap along and thus makes way for itself without injury. The tip of the root seems to be sensitive, as it turns away to avoid obstacles. The power of roots is enormous, sometimes splitting walls, trees, &c. It is of practical importance to remember this. The main distinction in roots is between the tap root and fibrous root. The tap root is very large and generally central. Root of palm and of corn is fibrous.

Stem.—The stems of many plants are under ground and are wrongly called roots. It is thus with the potatoe, which is really a stem, the "eyes" being really buds. So the stem of the fern being largely underground is often called a root. In Botany this is often called the root-stalk. In a strawberry plant the "runner" is a stem. The essential of a stem is that it bear leaves. Hence the definition of a stem is "that which bears leaves," and of a leaf, "that which is borne by the stem." When the stem is large and woody we have a tree; when not large, we have a shrub; and when a stem is not woody we call it an herb. When the stem is short, as in carrot, we say the leaves are radical. Taking the stem of an oak and examining the structure we find as follows: In the centre is (1.) the pith; then (2.) the medullary rays branching to the external parts, at which splits in trees may best be made; then (3.) the annual rings, by which we can tell the age of the tree, the outer one being whiter and softer, and called sapwood; next (4.) that growing ring outside the wood and inside the bark; here the wood yields most; then (5.) the stringy bark; and (6.) the cork bark. The oak is a specimen of what are called *exogenous*, *i. e.*, growing from the outside. The palm, a specimen of the *endogenous*, *i. e.*, growing-within class, has none of the six characteristics of the oak mentioned above—no pith, medullary rays, &c. The vascular bundles before spoken of, are very abundant at the surface, and are irregularly distributed. Pines are like the oaks in general character, but on account of peculiar characteristics are put in a class by themselves. The four classes of plants we want to notice and remember are, (1.) Thallogens—those having a mantle (mushroom.) (2.) Exogens, those growing from without, *i. e.*, oaks, &c. (3.) Endogens, those growing from within, palms, grasses, &c. (4.) Gymnosperms, pines; and lastly, (5.) Acrogens, those growing at the top; *i. e.*, mosses, &c. Branches are but stem structures, continuations of the stem. The term "leaf" is used here in a wide sense, and means every flat growth on the stem or branch, including the green or foliage leaves and the floral or colored leaves. In popular language only the green ones are called leaves. Some leaves are like scales and cover the flower bud. Leaves grow on the apex of the stalk, on the outside, and always acropetal, *i. e.*, the youngest is highest, and never a younger leaf below an older one. It is a universal law that no new leaves grow anywhere except at the tip of the stalk. The leaf is of the utmost importance in the life of the plant, especially the foliage leaf. They afford a very large surface for the

purposes of supplying food, breathing, and for purposes of evaporation, the surface being much more than of the ground beneath. Woods protect the soil from the sun and attract moisture, and the removal of woodland causes great changes in climate. Leaves absorb water, and are more to the plant than lungs and stomach, as they catch the food and manufacture it. The Pitcher Plant catches insects and imprisons them, and is thought to digest them. Only when green do they absorb and produce food. Green leaves show periodicity in growth, growing fastest in the strongest light. Even plants in the dark show this trait. Plants must have green leaves or an equivalent. The cactus stem acts as a leaf, broadening out. Here the leaves are rudimentary. So acacias have no leaves, but the stem flattens out, and performs their functions. The parasitical plants have generally no *green* leaves, or else none at all. Some trees are periodically leafless. Insects may kill trees by cutting off the leaves, although trees show great reserve power. The mode of branching is in accordance with the necessity of distributing leaves, the stem growing smaller as branches are sent out. The leaf forms are in accordance with mode of life. If a tree has large leaves, they are generally much divided, small leaves not being so.

Summing up then we find the offices of the leaf is first, when green, to produce food; second, to consume it; third, to breathe. Its structure is (1.) a leaf-skin, containing stomates and hairs; (2.) leaf-flesh, consisting of short cells with air-spaces between; and (3.) the skeleton of the leaf, consisting of fibres and ducts. As regards its veins (it being remembered that " vein " in Botany refers to the fibres in the leaf), we have the reticulated or netted-veined leaf, the parallel-veined, where the veins are parallel; (3.) forked, as the acrogens; and (4.) the cellular plants, as mushrooms. The leaves are arranged on the stem singly, one following another up the stem, arranged " alternately;" or are " opposite," being in pairs, two on a joint and opposite each other; or are "whorled," *i. e.*, several around the same joint in a cluster. The parts of the leaf are—the leaf-stalks, the axil, stipules, (little leaves at foot of stem), and the leaf-blade.

LECTURE III.—*Organs of Reproduction.*—One common mode of increasing trees in number is by cutting off a part and planting it away from the "mother." In some species this is the only way known, as we have only the female tree existing, or at least the male is not known, and no seeds mature. This is so with the weeping willow, which never grows from seed. In some mosses no seed is found. By this way the peculiarities of individual varieties are preserved, as of the roses. There seems to be a limit to this, however, as after awhile the variety seems to run down and become worthless. This is seen in the white potato. Hence new species often arise from the seed. This, however, is not reproduction proper, but merely propagation.

Reproduction Proper.—This is parallel with reproduction as found in the animal kingdom, as there are real sexual distinctions in the higher groups. One or two cells are set apart in the parent from the beginning, and have really a separate existence, although they receive nourishment and protection. These get larger and distinct and perform their peculiar function. These reproductive cells are of two kinds, of two sexes, and the male cell fertilizes the other. The Pollen in a flowering plant is the male cell, and is usually small, the female cell being much larger and growing after fertilization into a perfect plant. In the higher classes the reproductive parts are found in the flower; hence flowering plants are those which have reproductive organs.

Here the question arises, "What is a flower?" The essential parts are the cells—the pollen and the seed cell. The leaves are not essential to a flower. A true seed contains an embryo plant within it.

For ease and certainty we will now give some definitions. Ovary is that which produces ovules or young seeds: Seed is that which contains the embryo of a plant: embryo is the young plant in the seed: the germ cell is the cell in the ovule which becomes the embryo: Pollen grain is the sperm cell which fertilizes the germ cell: pollen tube is a growth from the pollen grain: the stamen is that which contains pollen. Only in flowering plants are pollen and ovules found. The reproductive cells of non flowering plants are called spores, so in moss the cell is of jelly and does not contain an embryo. Flowers are reproductive organs surrounded with leaves, the parts of the flower being homologous with the other parts of the plant. Thus in the flower we have a central axis, bearing leaves, modified according to function. The general description of leaves applies to the leaves of the flower except that they do not require to breathe, and so are crowded more for protection, and so when not green they have no part in nutrition. The arrangement and structure depend on the way they are fertilized; if they are fertilized by the wind there are large quantities of pollen and the flower is open; if by insects there may not be much pollen, but that is very bright to, attract the insects, and some flowers are arranged so as to keep out insects foreign to their purpose. Proof of the homology of the floral and the nutritive parts is found in the fact that they grow in the same way, and that spores are only metamorphosed leaves. The action of the flower on the plant is opposite to that of the leaves,—flowers give out heat and consume food. We can force a plant to grow larger by cutting off the flowers. The leaves close to the flower and unlike both foliage and floral leaves are called bracts. The daisy is really a head of flowers, not a single one, and the bracts are beneath.

We have now to say a word about Inflorescence or the method of arrangement of flowers on plants. First we have a single flower; then we have the *raceme*, consisting of a main stalk and branches, the branches bearing flowers; then we find the *spiked* arrangement, the flowers sessile on the central or main stalk; next comes the *umbel*, where all flowers spring from one point. In these last the youngest flower is always uppermost, and the method of inflorescence is "indefinite" *i. e.*, has no limit, we can not tell when it will stop. This kind is also acropetal, *i. e.*, youngest flowers on top. Next comes the *cyme*, in which a flower always terminates the main stalk, and the central and uppermost one is the oldest. This variety has lateral branches. The arrangement of the flowers is made much use of in classifying plants. We need to use care in distinguishing the parts of plants, as for example in the calla lily, where the white part is a bract, and not a flower, as often supposed; the flower is the central or fleshy part. In describing a plant state its subkingdom: follow the order of growth,—root, stem with its branches, leaves and appendages, the inflorescence and bracts, the flower, fruit, and seeds with their number and structure.

LECTURE IV.—*Structure of the Flower.*—There are about 150,000 species of flowering plants, and the work of dividing them into orders depends on the structure of the flower. The method of the veining of the leaf enables us to divide plants into endogens and exogens, but the, flower-structure enables us to divide more minutely. The flower consists of four rows or parts; first two rows of perianth leaves, called the calyx and corolla; and then two rows of essential organs. The calyx are the outermost row, leaves are *sepals*, and they are often green: the corolla is the inner row, consisting of *petals*. These are the non-essential organs of reproduction and are called the perianth. Some plants have only one row of perianth leaves, some have

none and the flower proper is naked or protected only by *bracts* or chaff as in grain. It is often difficult to distinguish between sepals and petals.

Now as to the essential organs of reproduction. As stated there are two rows. The outer row consists of *stamens*, which are inside the corolla, and are the parts which produce the pollen. The pollen is in the head or *anther;* the stalk is called the *filament*, and the "dust" is the pollen, and is the male or fertilizing part of the flower. (Any word in Botany containing "andr," meaning "male," refers to the stamen, as dekandros, meaning 5-stamened.) Linnæus made his distinction of species depend on the number of stamens. This method was found inconvenient and was given up. The next row of organs is in the centre and are named *pistils*, from their resemblance to an apothecary's pestle. The pistil has three parts; a lower, called the *ovary*; the stalk, called *style*; and the top called *stigma*. An ovary when ripe is named a carpel. Strictly, however, a carpel is one part of an ovary, as the latter has sometimes several divisions containing seeds, and each of these divisions is a carpel.

All the floral organs rest on the receptacle or top of the stalk, called the *thalamus*, or couch. It is usual to describe the receptacle first, and then the other parts of the flower, commencing on the outside, and working inward, in the order, receptacle, calyx, corolla, stamen, pistil. The number of parts in each row is generally similar, though often there is a double row of stamens. Thus, if the number running throughout be 5, we might have 5 sepals, 5 petals, 10 stamens, and 2 pistils. The formula used in describing flowers is as follows:

$$\text{Cal. (Se.)}_{n,}\qquad \text{Co.}_{n.}\ \text{(Pe)}\qquad \text{St.}_{n+n.}\qquad \text{P. (ca)}_{n-m.}$$

This is called the floral formula of symmetry. The relative position of parts is usually alternate, *i. e.*, an outer row with spaces between, and then the inner row filling up or covering those spaces. This rule is a very general one, and when the arrangement is different, marks a new order or species.

The question now comes up, why do flowers differ? The differences depend on several general causes. (1.) The type numbers may vary. Thus exogens are generally of the 4, or 5, type; endogens of the 3 type. The sign used to indicate the numbers prevailing throughout a plant, is the number over the radical sign:— $^{3}\surd$, or $^{4}\surd$, $^{5}\surd$.

(2.) Non-development of parts. We must always be prepared for the absence of some one or more of the parts; it may be a part of the perianth or the entire perianth. Thus the flowers of the hazel are between bracts. Some flowers have no stamen, and others no pistil. This occurs in the melon, and there are male and female flowers, distinct in the same plant. Sometimes neither stamen nor pistil appears, and the flower is then said to be abortive, or nonproductive. So, often there is no style, only the ovary and stigma.

(3.) Unequal development, as when the calyx leaves are dissimilar, or the corolla leaves are not like each other, as in the snap-dragon. If the leaves are unlike, they are called irregular. An irregular flower never terminates a stalk. The irregularity of flowers is correlated with the visits of insects to fertilize them. These so called irregular flowers are not so irregular as they seem, they having bilateral symmetry. There are two kinds of symmetry; that "all around," and bilateral. We often find the stamens irregular, some long and some short. (4.) Cohesion of similar parts. This is one of the very first points to be looked at, as for sepals connected with each other, and in same way, the petals. We often find nine petals united in one, and one separate. Exogens are divided into *polypetalous*, including those whose petals are not united; *mo-*

nopetalous, those with petals united; and *apetalous*, those with no petals. So, often two or more parts are united in the ovary.

(5.) The next point is to be noted; it is *ad*hesion, not *co*hesion. Adhesion is the union of dissimilar parts, as sepals to petals, petals to stamens. Cohesion is the union of like things, as sepals to sepals, petals to petals, &c. A flower consists of four parts, any one of which can be united to its neighbor. Another point to be noticed here is that the flower may be upon the seed vessel, or below it so as to enclose it, or may be around it. The following cases occur:

(a.) All the simplest floral whorls arise directly from the receptacle, and are cases of inferior flowers.

(b.) The calyx may unite with the seed-vessel and be carried up from it together with the petals. The fuchsia is a good example of a superior flower. First, there is the cube of the calyx or seed-vessel, then the calyx, then corolla, stamens and pistils.

(c.) There is an intermediate stage when seed-vessel is in the middle, and the calyx, &c., around it. This is called perigynous, and sometimes "one-half superior." The other modes are called epigynous and hypogynous.

(d.) When the flower is inferior, but the stamens are borne upon the petals or corolla. This is called epipetalous. (In describing, give first sub-kingdom, as flowering-plant, exogens, whether polypetalous, &c.; then location of flower, whether inferior, superior, &c.)

(6.) There may be an excessive multiplication of parts. Thus in the buttercup there are very many stamens. (In Botany the sign "∞" means "indefinite.")

(7.) Flowers may have extraneous parts, or those not corresponding to the normal parts: *e. g.*, the strawberry has an outer calyx. So some flowers have a crown growing out of the petals. A common part found in flowers is a nectary, a scale at the base of flower, containing honey.

(8.) The receptacle often takes a peculiar character; sometimes it is small, and sometimes is large and fleshy, as in the strawberry and fig.

These then are the modifying causes. How far are flowers subject to them? The answer is that there is not a plant but has some peculiarity.

The calyx leaves are usually green; those of the corolla mostly colored; yet the calyx is often colored when the corolla is small, and the calyx is then said to be petaloid. Some plants with brilliant flowers do not succeed well in being fertilized; they have a secondary flower near the ground of sombre hue, where a large number of seeds grow. These appear late in the season, and have, and need very little pollen. Bright colored leaves attract insects to them, which do service to the flower by helping the pollen get to the seed vessels.

LECTURE V.—*Essential Organs of Reproduction.*—Stammate or barren flowers are such as have no pistil. Pistillate or fertile flowers are such as have no stamens. Abortive flowers have neither stamens nor pistils; and perfect flowers have both. Stamens are of the nature of leaves. One evidence of this is found in the fact that the inner petals of water lily are partly like leaves and partly like stamens, having pollen on them. These are intermediate between stamens and petals. Many of our cultivated flowers have petals instead of stamens, as the flowering cherry; the inner stamens becoming petals, as in the spiræa. This is another proof. Another evidence is that their position is intermediate, alternate with the petals. Within the head of the stamen are pollen grains, and these have small spines on them for catching in the hairs of insects, and so of being carried to other flowers for the purpose of fertilizing. It is very easy to examine the pollen grains in a young stamen by the aid of a microscope. When the flower ripens the

stamen opens in some particular way. It may do so in a longitudinal slit, which is the most general way; often little holes called pores come in the top; or a third method is by having little doors or valves which permit of the pollen getting to the seed vessel. Each grain of pollen is a drop of protoplasm with a wall having on it beautiful markings. Attempts are being made to classify flowers from their marking. A curious point is that some kinds of pollen, as for example, that of the pine tree, is carried by the air to fertilize other flowers. Such grains of pollen have a sort of little balloon, or rather two to support it in the air, and are thus correlated with their mode of fertilization. In this way when the plant is low, the stalk bearing the pollen is sent up into the air, and the pollen is quite large and loose. In those plants fertilized by the aid of the wind, there is generally no bright color to attract insects, and no honey, and such plants are called anemosphelous. Those which are fertilized by insects have bright colors and honey in order to attract insects. Where plants have male and female flowers on the same plant, but each distinct, the aid of insects is necessary. An example of fertilization is found in the date palms of Egypt. They are fertilized by male palm branches brought in from the desert, all the date palms being female. During Napoleon's Egyptian campaign the business of bringing in male branches was neglected and there were no dates that year. Pollen can be carried a great way and not loose its fertilizing powers. Rain causes pollen grains to swell and burst prematurely, and hence rain injures fruit crop if it comes in time of bloom. The pollen must be placed on the stigma of its own kind of plant, but usually not on the same flower. The way insects seem fitted to fertilize plants is wonderful, as for example, in Madagascar, one of the orchid family has a spur nearly a foot long, with honey in it. Mr. Darwin said a moth with a proboscis of nearly that length, would be found (which would fertilize the flower), and in South America such a moth has beon found; but not as yet in Madagascar. Thus these plants are fertilized or increased in four ways: (1.) By aid of the wind; (2.) by aid of insects or humming-birds; (3.) the cleistogonous flowers before spoken of; and (4.) by slipping or budding, the last really being extension. In describing *stamens*, then, describe (1.) their number; (2.) their insertion, or how related to the pistils or petals and calyx, whether epigynous, hypogynous, or epipetalous; (3.) their position as to petals, whether opposite or alternate; and (4.) their size, whether equal or unequal. In describing the *anther* or top of the stamen, first the number of cells; (2.) the face of the anther, whether it looks inward or outward; when outward, they fertilize other flowers; and (3.) the mode of opening, whether longitudinally, or by pores, or by valves. We make a great deal of use of the position of the petals. A point to be noted in describing the stamen is as to whether the filaments or stalks are separate or joined together.

We have next to do with the *Pistil*. All floral organs are designed to produce fruit. The pistil ls composed of three parts of ovary, style, and stigma. The stigma is on the top of the style, and is the only part of the plant not protected by a skin. On this the pollen falls and attaches because of the lack of a skin. The pistil corresponds to an unfolded leaf. This is best shown by a pea. On opening a pod it will appear that the leaf was folded in, and that the valves were borne by the edges of the leaf. In the wallflower the pistil is composed of two leaves, and has two cells, *i. e.*, is bi-carpellary. Our flowering cherry has petals or leaves instead of stamens and pistils. Thus flowers may have more than one leaf. When there is more than one carpel they are generally united, and thus the ovary is composed. In violets three leaves are joined together in one chamber, and there are seeds in three places. The places

where the seeds are, mark distinctions. When they are on the walls, they are called *parietal*; when at the centre, they are *axillary*. In compound ovaries the walls may be joined in different ways; (1.) the edges may be joined, and the ovals grow at the edges or junctions, the edges just touching; or (2.) can grow on and meet at the centre, then the seeds are at the axis; an additional case is when the seeds are axile, but not enclosed by a wall. In describing the pistil, tell (1.) whether it is superior or inferior to the surrouuding parts. It may be inferior to the calyx, or superior- When the calyx, &c., is superior, the ovary, &c., is inferior, and *vice versa*. (2.) Whether simple or compound. Then (3.) tell about the dihiscence of the fruit, how it opens. (4.) The kind of fruit. We often have fruit with only one seed in it, and that opens only when the seed begins to grow.' This led to calling fruits of this kind seeds. Fruit is really the seed-vessel containing or enclosing seeds, while it has popularly been restricted to those plants which bear fleshy parts enclosing seeds, as berries, apples, &c. The kinds of fruit are, *nuts*, those with hard shell containing the fleshy part and germ; *berry* is a fleshy pulp enclosing seeds; *drupe* is fruit with fleshy exterior enclosing a hard part or shell, and that enclosing the germ; *pome*, of which an apple is an example, is fruit formed by the receptacle growing around the seeds and enclosing them; *capsule* is the kind of fruit most extensive, and is a dry seed; *legume* is a bean (a special form of above); *cone* is the fruit of the pine; and a *key* is the seed for example of a maple, having a wing to to it.

A great mistake has been made in plants in regard to the purpose of the fleshy or edible parts of the fruit. It is most likely that these grow in this form, in order that they may be eaten, and the seeds within having hard coverings are protected from the action of the gastric juice, and are afterward expelled, and thus the species is propagated. Therefore the prime purpose of the flesh is probably not to furnish food, but simply to extend the species. So, for this purpose some seeds are furnished with prickles or spines to be carried by the wool of sheep, &c., to other places.

The most important characteristics of a flowered can be gathered into a condensed plan so as to show at a glance the species of a flower. Thus, below is the analysis of a Star of Bethlehem. Taking the calyx, we find its leaves are three in number, and put down under *No.*; then we see how far they cohere, and find that they are separate, as under cohesion we put down "not united." Next we look to see how it is placed to other parts, and find it below; and so we put under adhesion, "inferior," and so on throughout, corolla, stamen and pistil:

MEMBER.	No.	COHESION.	ADHESION.
Ca. (Se)	3	Not united.	Inferior.
Co. (pe.)	3	" "	Inf. to seed vessel or hypogynous.
Sta	6	" "	" "
Pi. (Ca.)	3	Untted or Syncarpous.	Superior.

LECTURE VI. We next want to find out some of the principles of the classification of plants. We shall have very little difficulty in learning this, having a knowledge of what has gone before. Plants are divided first into flowering and non-flowering plants. We have already divided these into exogens and endogens, but the flower as well as the leaf furnishes and indication of this classification, those on the $^{4}\surd$ or $^{5}\surd$ type being generally exogens, and those of the $^{3}\surd$ type being endogens. Another or third class are the gymnosperms, or those with their seeds naked, as the pine family. Still another way to tell exogenous plants from endgenous is by the cotyledons, or seed leaves; when the seed contains two cotyledons the plant is exogenous, when only one it is an endogen. Rhubarb may mislead

one it having three. Now having the classes exogens, endogens, and gymnosperms, how may we subdivide them into their sub-classes. We look (1) to see whether their flowers are complete or incomplete; (2) to see whether they are monopetalons or polypetalons; then (3) we notice whether their flower is inferior or superior to the seedvessel, or whether, like the roses, it is perigynous, i. e. around the seed vessel.

Thus we have The Vegetable Kingdom, under this we have the sub-kingdom of Flowering Plants, and these divided into Class I—Exogens or Dicotyledons, which have (a) Exogenos stem, (b) nettled-veined leaves, (c) Flowers on $^{5}\surd$ or $^{4}\surd$ type, (d) Dicotyledonous embryo. Then following out our plan as given above we have

Sub	Class	I	Polypetalons	inferior	exogens.
"	"	II	"	superior	"
"	"	III	Monopetalons	"	"
"	"	IV	"	inferior	"

In classifying endogens, we do not use the terms polypetalons or monopetalons since they are not needed, hence we speak of and largely rely upon the position of the flower as regards the seed vessel, i. e. whether inferior or superior.

Then after the endogens (sub classes III and IV) we have sub-class V, the incomplete exogens, or those with no perianth.

We shall next consider the seed. This is a misconception of the true meaning of fruit. The fruit is not merely the *fleshy* part, but distinctively is that which contains the seed or *is* the seed. The two distinct marks of flowering plants is (a) producing pollen (b) producing seeds, (the reproductive structure) which contain a part called in Botany the embryo. The essential of a seed is that it contains a young plant or embryo. This is often, however, very small. The embryo may be surrounded with food and still further covered with a seed coat. We may state here that the seeds are made great use of in the science, and are very advantageous to it.

THE LIFE HISTORY OF A SEED.

There are twelve stages in the life of a seed, and these we shall now notice. This is one of the late advances made in the Science and is an important one. (1) The first stage is its first appearance on the carpel leaf, it starting like a wart on the part of the carpel called the placenta, and consisting of a mass of cells. It has been called the nucleus, but this is an unfortunate and perhaps an unsuitable name so we will call it the primitive seed mass and refer to it under that name. (2) A wall grows out from below and then a second wall, the two forming a double coat which remains to the very last of the seed. These two coats do not entirely enclose the seed, but a small opening, called the microphyle, remains at the peak of the seed. This double wall and microphyle is seen very plainly by soaking a pea and then examining it. (3) One of the cells of the primitive seed mass grows larger than the others and becomes the embryo sac where the young plant arises and undergoes part of its development. The sac forms a chamber into which the microphyle opens. (4) In the interior of the embryo sac cells arise, grow freely and are called germ cells, consisting of a mass of protoplasm. The cells formed below become the food of the embryo. (5) At this stage the pollen sends down a pollen tube to fertilize the ovules or germ cells, with which they become united. (6) The germ cell lengthens out, divides into a number of cells, and becomes what is called the pro-embryo. The germ cell is not the embryo but is really its parent. Thus within the seed there is a concealed alternation of generations which has escaped observation until late years. It is especially to be noted that the sexual process

leads to the pro-embryo, not to the embryo. (7) The terminal cell produces a bud and this becomes the true embryo This process is not sexual. These last two stages are really the key to the entire subject. (8) The embryo thus formed has several parts, (a) the root end or radical stem; (b) the cotyledons; and (c) the plumules or young leaves. The plumules are often very numerous, there being twenty-four or more in the pea and perhaps a hundred in the almond. As stated in the first part of the lecture cotyledons are an aid in classification, one indicating that the plant producing it was an endogens, and the presence of two marking an exogens. (9) After growing for a time the embryo remains in a quiescent stage in order to hibernate. This takes place when the seed is ripe. Seeds will retain their vitality for a number of years if kept dry, but it is not probable that the stories of wheat growing from seeds enclosed in the wrappings of Egyptian mummies are true. Seeds can endure the winter as they have little water in their composition. (10) The stage of growth at which the period of rest comes varies in plants, The orchid family take this rest very early, before the embryo is formed. The buttercup has an embryo very minute and a small store of food. The Morning Glory has a very large embryo with large leaves and an abundance of food around it. The cherry has a large embryo but a very small amount of food, hardly more than a trace, and the same of the bean. This is similar to what we found in Zoology, some animals, as the Kangaroo, bringing forth their young very early and very immarure. (11) Considering the external arrangement we have various arrangements. One point just here is that the radicle or root part always lies toward the microphyle. When the seed is erect the radicle is turned up, the microphyle being on the tip. Here the root seems to be upside down. Then it is very common to find the embryo inverted in which case the microphyle is at the base and the radicle downwards. Aother variation is that the embryo may curl around and the radicle appear near the cotyledon. (12) Seeds may be complicated by additional and abnormal parts. Thus the nutmeg has little plates at its base which are not normal to most seeds and which are much used as a condiment. This addition—mace—has been and still is an important article of commerce. It has been called the aril. This is found in gymnosperms, the aril being a sort of partial covering. Hairs on seeds are of this character.

Before leaving the seed it is well to call attention to its importance. It becomes most useful on account of the large quality of food stored up in it, and this food is not necessarily stored up for our benefit but most likely for its own, it doing us the most good when it serves its own ends. viz., the propagation of its kind. The cereals are the most important among the seeds, rice alone supporting more people than all else together. The cultivation of these is extending and in Europe they are now cultivating Indian corn. Seeds contain all substances needed for food. The rind or chaff of wheat is flinty. Seeds also produce oil, poisons, and other important articles of commerce.

LECTURE VII.—*Flowerless Plants.*.—We can give only a mere sketch of these and will commence at the foot or the lowest classes. Before going on with these however we notice the group of *Bacteria*, which are the lowest plants. (The lowest animals are called Protozoa, the lowest plants Protophytes.) These are of special interest now as they are said to be the cause of many diseases, especially those of a malarial nature. If we set aside for a few days a tumbler of water it will become covered with a thin pellicle consisting of Bacteria. Each plant is composed of a zigzag chain of rods, moving spirally, and reproduces by transverse division. Small pieces of these are constantly floating in the air ready to be breathed and taken into the system. Ma-

larial districts are worse in Summer after dry weather because so many of these Bacteria are released by the evaporation of the water. There are many species of different forms, specks, rods, &c., but none are branched. They make fluids milky, but in the blood can only be detected by the microscope, as they mix through the corpuscles. They also cause the putrefaction of meat which, if kept out of their reach, might be saved for years. It is on account of the presence of these that a wound received in the dissecting room is so dangerous. They are also charged with spreading Diphtheria, and their presence is known in Fevers, the period of the height of the fever and its decline and rise probably corresponding to the time of maturity, decay, and growth of the Bacteria. The presence of these is known in fever but it is not certain yet whether they are the cause of disease or only the accomeaniment, and the investigation of this part is of the greatest moment and interest to us all. A species of fowl-cholera has prevailed which seemed to be caused by this, and some of the germs kept for a long time and then inoculated into chickens, has caused a mild type of the disease in the inoculated fowl. In the same way cattle have been inoculated to induce a light attack of the splenic disease and have been free from it afterward. This subject is in its infancy, however, and we must not place too much reliance upon these experiments as yet; still a complete investigation of it may give us great command over many kinds of disease; the investigation, however, is of great difficulty because of the minuteness of the plants. They can be killed by a heat something less than that of boiling water, and are rendered torpid by cold.

Next we take up the *Diatoms*. If we get up some of the sediment of a stream or some red swamp ooze or the stomach of a pollywog or water snake we shall find a large number of these with the aid of the microscope. They multiply in two ways; (1) they subdivide, each part becoming a perfect plant; (2) by conjugation, two plants of similar organism coming together and coalescing into one. New vigor is gained by this, and then subdivision takes place. They consist of a double cell, resembling a pill box and its lid, one fitting to the other; this is enclosed by a wall of flint containing a soft gelatinous protoplasm having concealed within it green matter. It secretes the flinty substance from the water and also its food. These shells are often very beautifully marked and furnish tests for microscopes by the intricacy of their tracings. There are, it is believed, about one thousand species of these, and about seven hundred are known. They are of all shapes, and artists might from the tracings on their shells get ideas of new patterns. Some Diatoms may have their shields perforated to admit of locomotive power being exerted (as they move), but their method and means of moving are not known. They are found both in salt and fresh water and in the polar region the ice is often tinged with them. Their shells often form banks in the sea, the mud of the polar seas is largely composed of them, and they form layers or strata of the Earth's crust. The city of Richmond is situated on a bed of these eighteen feet thick, and Guano manure contains abundance of it, the guano being the deposits of birds which have fed on fish, which ate Diatoms.

The next class are *Desmids.* These are found in fresh water only, are of a beautiful green color, giving to stagnant water its green tinge. They have the power of motion and multiply by division. They are often green and then turn red in reproduction. The Volvox is a beautiful species of these, being a moving ball of green matter. Next come the Conferves found in fresh water ponds, masses of green, and matter strung together which are cells attached end to end. Some of these have a peculiar non-sexual method of repro-

duction very like the encysting of animals. Spores go off from these green cells and swim through the water, then germinate.

The division of the lower plants is doubtful and not yet determined. That here given is the easiest to learn. Next come the algae or sea weeds. These have a compound cellular structure and may be one plate or many plates of cells, and are often very large and beautiful; some of them rise from the bottom of the sea and have stalks three hundred feet long. They are also supplied with air bladders to keep them afloat. This stalk and root seem of no use except to keep them stationary as they take their food from the water. Sea weeds are Thallophytes and have no stem. The stalk is not a true stem, there being no fibro-vascular matter in it, and it is merely a thickening of the leaf. (The term *Thallogens* includes all that have been named and spoken of after the Bacteria). These plants fertilize by means of what are called Spermatazoids, which are little things resembling animals with cilia. These have the power of motion in water, and take in flowerless plants the function of pollen in flowering plants, fertilizing the ovule. (Sea weeds are divided, according to color, into the red, brown, and green sea weeds.) Red sea weeds have also a non-sexual method of reproduction. The surface is covered with black specks which are sacs containing four spores, and hence are called Tetraspores. Next come the *Fungi*, which are of the most practical interest of the flowerless plants. The Bacteria might be included here, and to this group the Parasitical plants belong. To this class belong the mushrooms, toadstools, dry rot, yeast-plant, mildew, rust on leaves, &c. There are a number of edible mushrooms but the difficulty is to distinguish those which are edible from those which are poisonous; the mushroom comes nearer to animal food than any other plant. Their parasitical character entails special adaptations. (1) The truly vegetable part is small, the roots of a mushroom alone being vegetative and all above the ground is reproductive and no green matter is required. (2) The reproductive parts are especially developed, the spores being very numerous and small, and these parts thus are in excess. (3) The life-history shows many variations. They often reverse the order of plant life, produce heat, pollute the air, live on animal matter. They grow on live caterpillars, in rotten trunks of trees, some from volcanic ashes, from walls (perhaps the Leprosy of the Wall spoken of in the Mosaic Law was a fungus growth on the walls). One destroys the silkworm, another in the enemy of the grape, and some are phosphorescent. The potato rot is caused by fungus growth. The spore of the fungus sends down suckers into the potato, causing the rot, and then sends up a kind of stalk bearing non-sexual spores, which are again scattered. If a dead fly be left a day or two, a fungus growth arises from it somewhat club-shaped, enlarges and gives out spores. There is also a sexual reproduction by ovules and a fertilizing growth. The " meal fungus " has also two kinds of reproduction. Important discoveries are being made constantly in this class. Thus it has been found that the cluster cups on the Berberry contain spores which are carried by the wind, and, alighting on the fields of wheat, cause what is called the " rust " on wheat. In the same way the cedar apple is found to be a fungus growth, which causes a disease on the leaves of apple trees. Summing up the characteristics of the Fungi they are parasitical; they are thallogeus, having no distinction of stem and leaves and no fibro-vascular structure ; they have a peculiar life history ; a great abundance of spores with small vegetative parts, and are related to the Bacteria. Next come the Acrogens, having a true stem. These are Mosses and Ferns. Mosses have a true stem and leaves and a capsule covered with a sort of cap under which is a lid, which opened, discloses a

number of teeth inside the capsule which, being "hygrometric," allow the seeds to escape in dry weather. Then come the Ferns or true Acrogens. These have true and complete stem, leaves and roots. The ferns around here, as stated before, have their stems underground ; elsewhere there are the tree-ferns with stems out of the ground. In former ages the ferns were larger and more abundant and contributed very much to the coal formation.

The mode of reproduction is of general interest as it shows two stages, the acrogens and thallogens. On the back of the frond or leaf are spore-cases. Around the edge of these is a sort of elastic band which, under the sun's rays, contract and expel the spores. The sperm on germinating becomes a prothallus, which is an intermediate stage in the growth of a fern. This pro-thallus produces an ovule, and along the edges chambers, which give out spermatazoids to fertilize the ovule. Thus the pro-thallus bears two reproductive parts—the male organs giving out spermatazoids, and female organs in the sac or ovules. After fertilization an embryo results, and the embryo becomes not a seed but developes into a fern. Here then we have the important discovery of an alternation of generations. We want to notice here that the spore becomes a plant, not a seed ; a seed contains within it an embryo, and this is the essential of a seed. One of the latest discoveries is a wonderful one, which shows a harmony between flowering and non-flowering plants, and that is the close connection between the stage of the pro-embryo in flowering and the pro-thallus in non-flowering plants, the stage being the same. The pro-thallus is very small.

In former ages the acrogens were very large and then formed the trees of the world.